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Multiple wall weathershields for UHF aerials

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MULTIPLE WALL WEATHERSHIELDS FOR UHF AERIALS

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(RA-67)

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MULTIPLE WALL WEATHERSHIELDS FOR UHF AERIALS

Summary

Calculations have been made of the effective reflection coefficient, as a function of frequency, of cylindrical weathershields comprising one, two or three dielectric walls. The effect of a dielectric infill between the walls is also considered.

1. Introduction

It is common practice to mount u.h.f. aerials inside resin-bonded glass fibre cylinders which provide weather protection and, in some cases, structural support for the aerial. The cylinder wall represents a discontinuity at which reflections occur so that the radiation patterns and impedance characteristic may be modified. The nature and magnitude of the effect depends on the type of aerial and on the size of the cylinder, being significant when the radius is equal to or greater than one wavelength.

In the particular application for u.h.f. relay stations, a pole-type aerial having a cardioidal horizontal radiation pattern (h.r.p.) is required to be mounted in a 914 mm diameter glass-fibre cylinder. It was found[1] that when the aerial was mounted on the axis of a single-walled cylinder, its horizontal radiation pattern was unaffected but its impedance bandwidth was seriously reduced. Conversely, when the aerial was positioned near the cylinder wall, the impedance bandwidth was acceptable, but the HRP was considerably modified.

Two concentric cylinders with one quarter-wavelength inter-wall spacing will clearly have a lower reflection coefficient than a single wall, albeit over a limited frequency band. Alternatively, a greater bandwidth may be achieved by the use of three concentric cylinders at quarter-wavelength interwall spacing, whose wall thicknesses are in the approximate ratio 1:2:1.

The reflection coefficients of both types of system have been computed for Bands IV and V; in all cases considerable improvements on the single cylinder performance have been obtained.

2. Method of calculation

To simplify computation, the calculations have been based on the one-dimensional model of a plane wave incident normally on a series of parallel dielectric layers. The problem may then be treated as a series of transmission lines of different characteristic impedances, and the voltage reflection coefficient may be calculated from the overall transmission matrix of the system. Dielectric losses, which are in practice very small, are neglected.

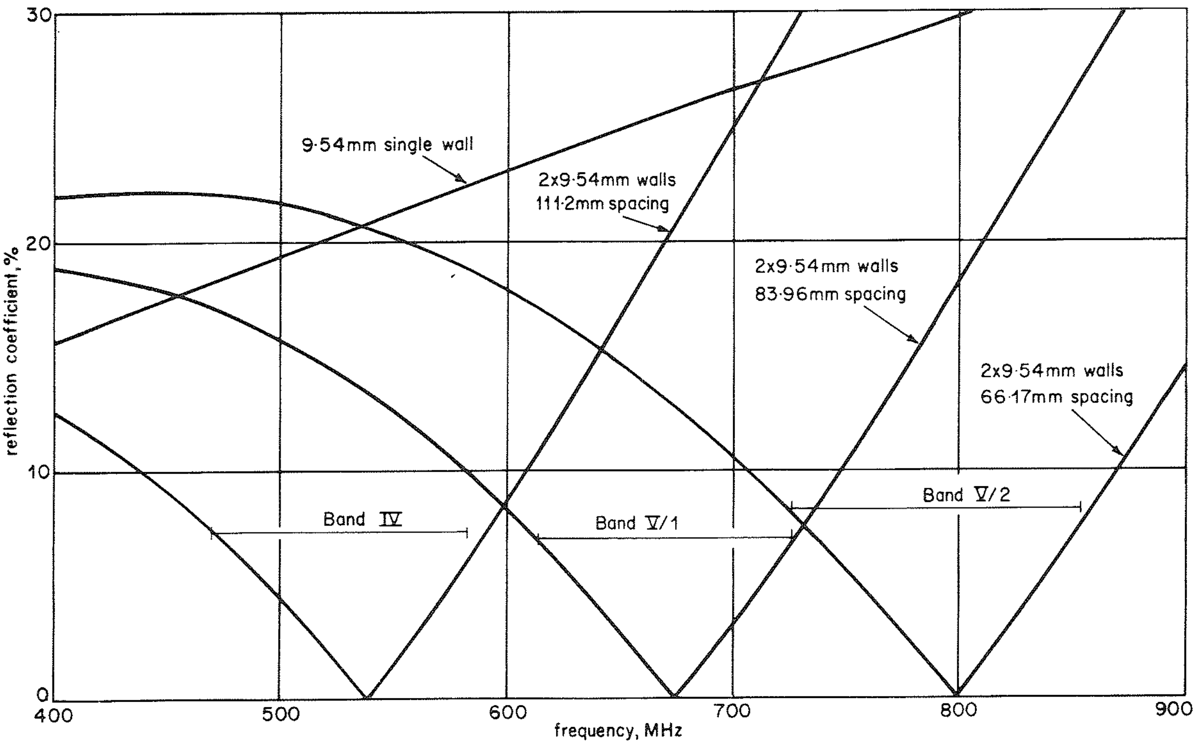

Fig. 1 - Effect of varying inter-wall spacing for 2 x 9·54 mm walls of dielectric constant 5·00, air-spaced

3. Results

3.1. Double wall

In Fig. 1 the reflection coefficients of three double-wall systems are compared with that of a single wall; in all cases the walls are 9·5 mm in thickness and of dielectric constant 5·00. The inter-wall spacings (i.e. separations between nearest surfaces) have been optimised for three frequency ranges: Band IV, lower Band V and upper Band V. It is clear that three different spacings are required to cover the u.h.f. television band if a substantial improvement over a single-wall cylinder is to be achieved.

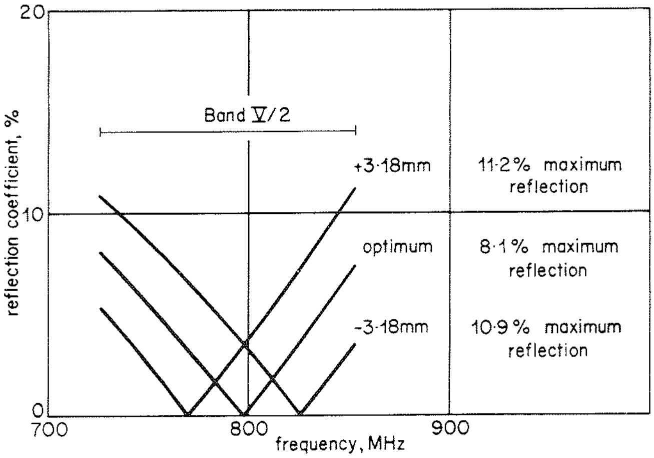

Fig. 2 - Effect of ±3·8 mm in tolerance on inter-wall spacing, air-spaced 9·54 mm walls of dielectric constant 5·00

The effects of a 3 mm tolerance on inter-wall spacing are shown in Fig. 2 for upper Band V (the most critical part of the band as far as tolerances in the system are concerned). In Fig. 3 the reflection coefficient is shown for different combinations of wall thickness; it can be seen that the walls should be equal and as thin as is consistent with structural rigidity.

As might be expected, the insertion of a dielectric infill between the walls reduces the bandwidth of the system (Fig. 4); the optimum spacing between walls also increases with increasing dielectric constant of the infill.

3.2. Triple wall

By using only one triple-wall system it is possible to obtain a reflection coefficient of less than 10% over the u.h.f. television band. This is illustrated in Fig. 5, which also shows the effect of a 3 mm error in the distance between walls. From Fig. 6 it can be seen that if the bandwidth is to be maintained, errors in wall thickness must not be greater than about 1 mm.

As in the case of the double-wall system, the bandwidth is reduced by a dielectric infill, and the optimum inter-wall spacing is increased; these effects are shown in Fig. 7.

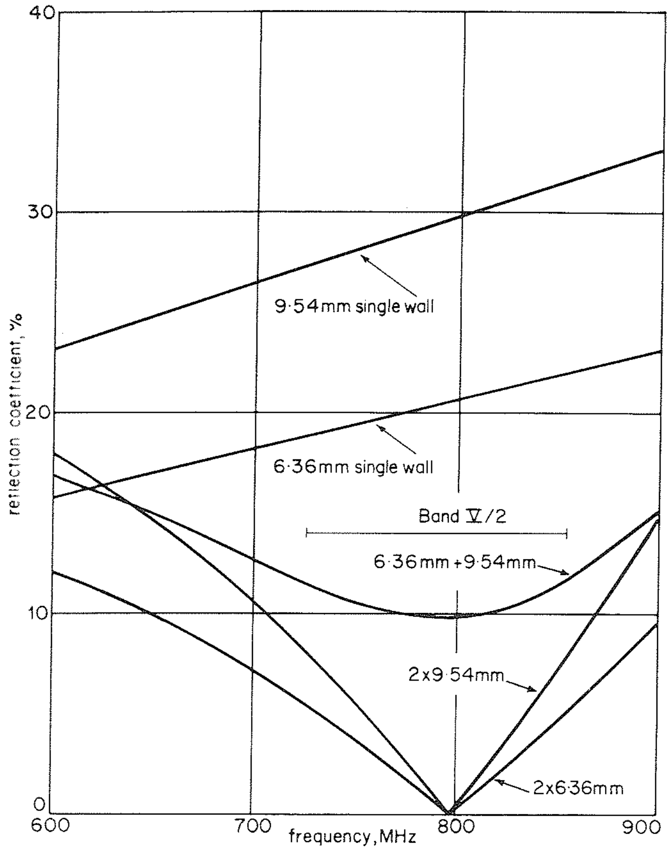

Fig. 3 - Reflection coefficient over Band V/2 for various combinations of wall thickness. Walls have dielectric constant of 5·00 and are air-spaced; spacing has in each case been optimised for Band V/2

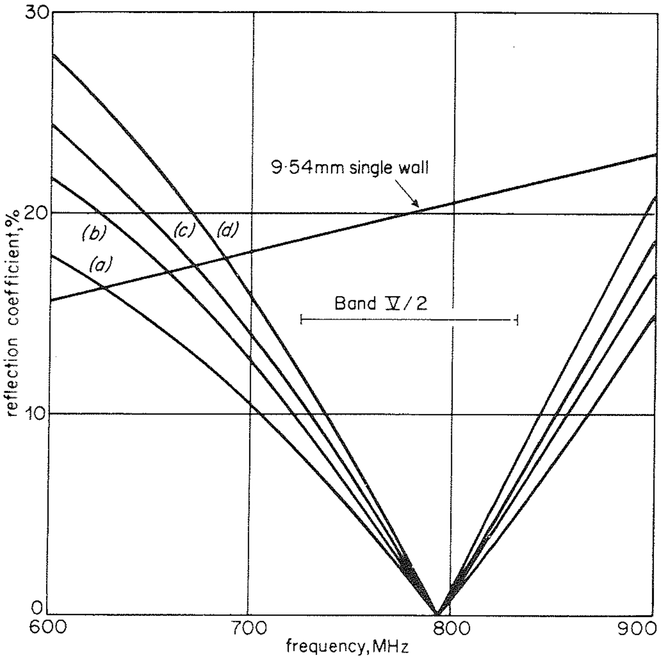

Fig. 4 - Reflection coefficient over Band V/2 for 2 x 9·54 mm walls of dielectric constant 5·00 with different inter-wall materials; spacings optimised for Band V/2

Curve	Dielectric Constant of Infill	Optimum Thickness of Infill (mm)
(*a*)	1·00	66·44
(*b*)	1·30	70·50
(*c*)	1·50	72·53
(*d*)	1·80	74·31

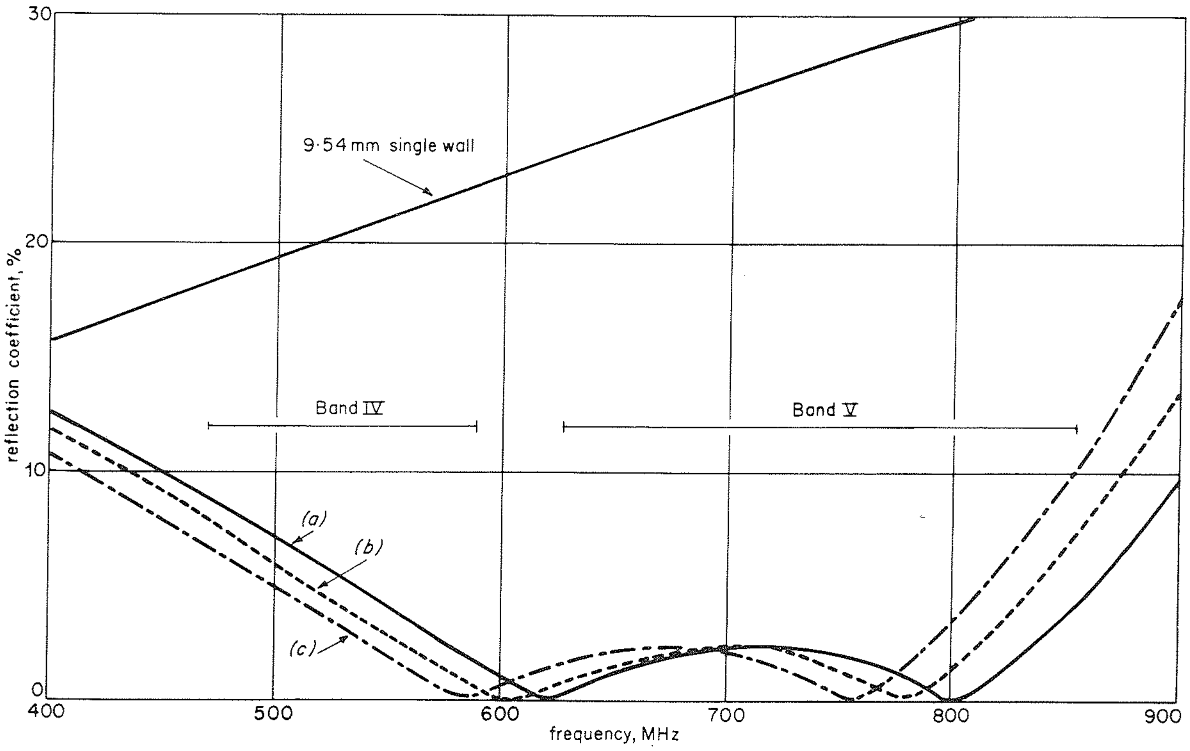

Fig. 5 - 3 cylinders: effect of spacing errors

Inner wall	5·09 mm	All of dielectric
Centre wall	9·54 mm	constant 5·00
Outer wall	5·09 mm	with air spacing

(*a*) —— −3·18 mm error in both air spacings
(*b*) - - - Optimum spacings, both 87·24 mm
(*c*) —·— +3·18 mm error in both spacings

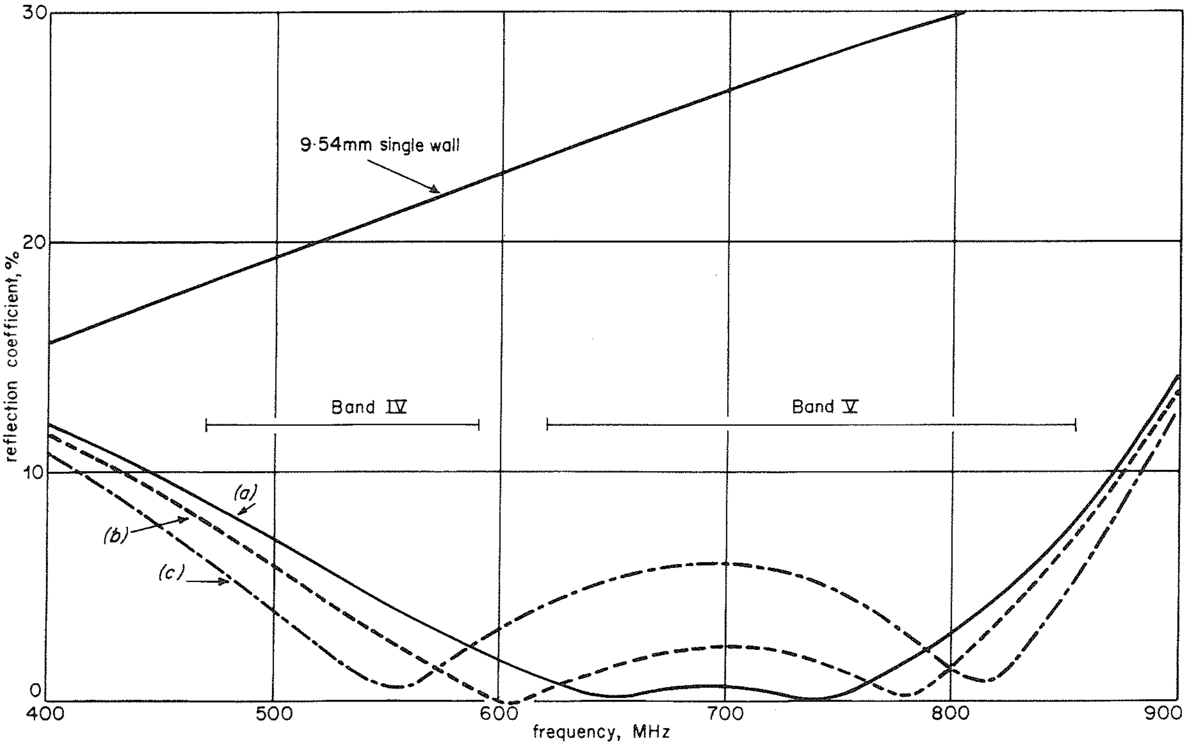

Fig. 6 - 3 cylinders: effect of tolerance in wall thicknesses

3 walls of dielectric constant 5·00, all air spaced at optimum distances. Centre wall 9·54 mm in all cases

(*a*) —— Inner and outer walls 4·75 mm, air spacings 87·01 mm (*b*) --- Inner and outer walls 5·09 mm, air spacings 87·24 mm

(*c*) —·— Inner and outer walls 5·73 mm, air spacings 87·42 mm

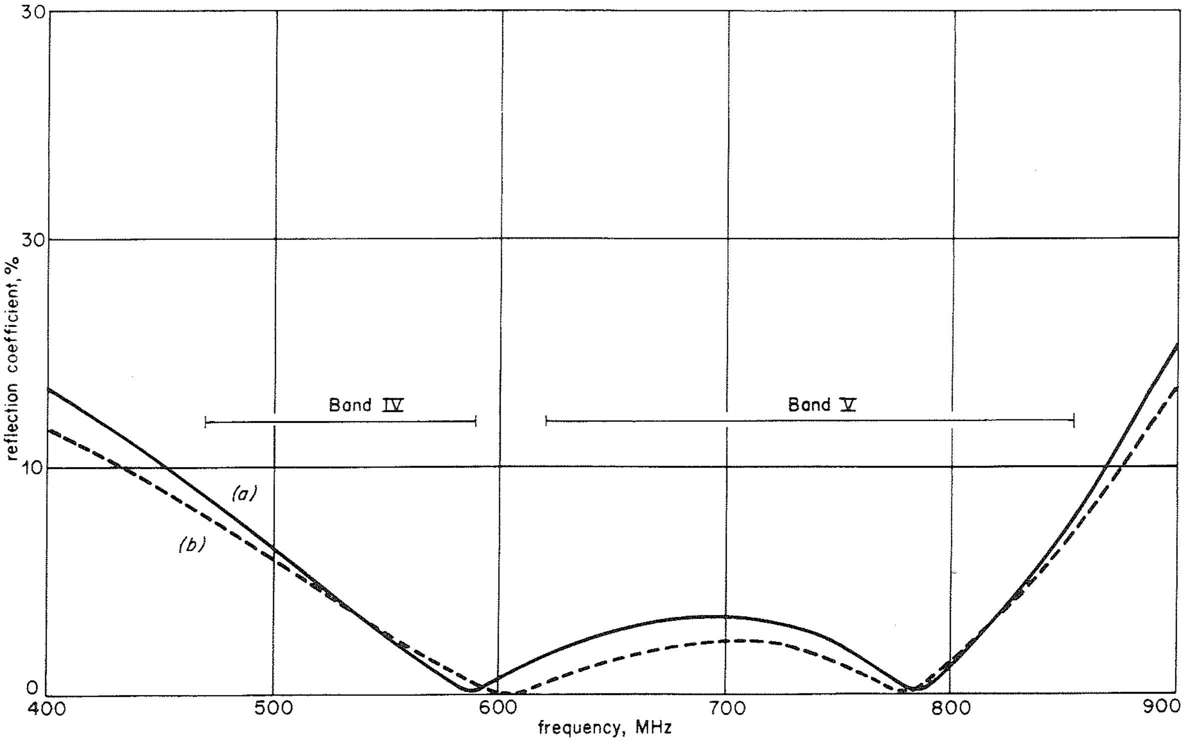

Fig. 7 - 3 cylinders: effect of dielectric infill

Inner wall 5·09 mm } All of dielectric
Centre wall 9·54 mm } constant 5·00
Outer wall 5·09 mm } and at optimum spacing

(*a*) —— Infill of dielectric constant 1·10, spacings both 89·60 mm (*b*) --- Air spaced, spacings both 87·24 mm

4. Conclusions

The use of a double-walled cylinder with the parameters assumed seems likely to give a maximum reflection coefficient in any one band of 10% – 12% compared with 15% – 25% for a single-walled cylinder. The improvement, though significant, is less than might have been hoped owing to the restricted bandwidth of the arrangement, and it is likely that the aerial would need to be rematched in situ. On the other hand, the triple-walled cylinder can give as good a performance over the whole u.h.f. band as the double-walled cylinder does over each third of the band. An even better performance would be obtained if separate models were made for Band IV and Band V. However, close tolerances need to be maintained to get the best performance from the triple-walled cylinder and there could be constructional difficulties.

In either case the aerial should be mounted on the axis of the composite cylinder as there may otherwise still be some disturbance of the h.r.p.

An alternative method of reducing reflections from a dielectric cylinder is to incorporate an inductive grating. This method is being studied.

5. Reference

1. U.H.F. relay station aerials inside 914 mm diameter glass-fibre cylinders. BBC Research Department Report No. RA-16, Serial No. 1968/18.

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